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Ferrybridge Performance Improvement

Lee Rhodes & Gary Dicker

Introduction

Lee Rhodes – Operations Manager

Career History

- Operations Manager at Skelton Grange (under construction)
- 20 years in the power sector with experience in oscillating kilns, vibrating grate, reciprocating grate and internal combustion systems
- CMgr FCMI of the CMI
- MSc in Engineering

Sur IPP CCGT

EDF - West Burton CCGT

BWSC - BREP

Enfinium Ferrybridge & Skelton Grange

New Lincs WtE

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Overview

- 6 Waste to Energy plants in the fleet with a combined processing capacity of over 3m tonnes per annum, equal to 11% of the U.Ks generated residual, commercial and industrial waste.
- 2 of the facilities are CHP
- £1.7b investment in CCUS

Source: Company information

Ferrybridge 1

Overview

- Processing capacity of 725,000t
- Electricity output 86MW Gross
- COD since August 2015
- HZI built plant.
- Innospin ACC OEM
- 2 boilers into a single turbine configuration

Steam Cycle Efficiency Issue

Collaborated with a consultancy group defining performance via:

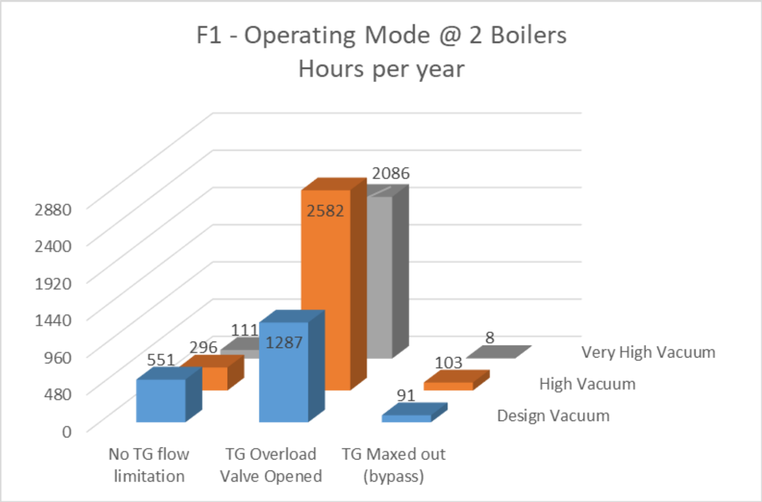
F1

1. Mass flow through TG – current load factor demonstrated turbine operating 84% with overload valve open
2. Vacuum- Plant operates at design vacuum (70mb) only 27% of the time.

F2

1. Mass flow through TG – current load factor demonstrated turbine operating 97% with overload valve open
2. Vacuum- Plant operates at design vacuum (70mb) only 46% of the time.

Therefore, ~5000 hrs where vacuum improvement would bring benefits at F1.



At Stake

2980 hrs	2200 hrs
From 92mb to 70mb	From 145mb to 70mb
Measured Steam Cycle Efficiency	
1,56 MWe	3,99 MWe
Steam Cycle Model	
1,65 MWe	4,59 MWe
Per Year	
4500 MWhe	8800 MWhe

Operational Excellence

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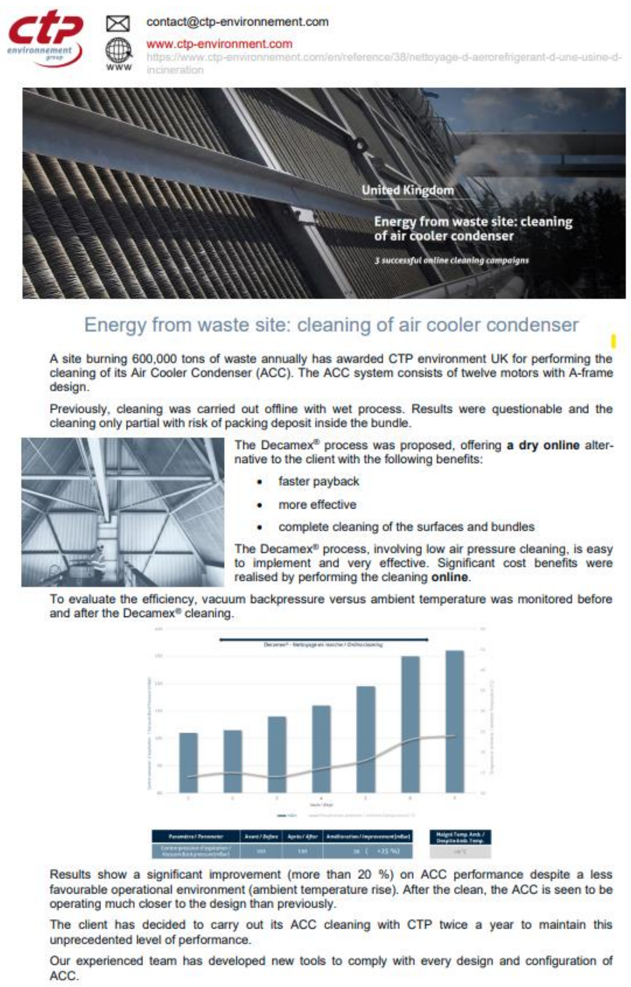


contact@ctp-environnement.com
www.ctp-environment.com
https://www.ctp-environnement.com/en/reference/38/nettoyage-d-aerorefrigerant-d-une-usine-d-incineration

Energy from waste site: cleaning of air cooler condenser

A site burning 600,000 tons of waste annually has awarded CTP environment UK for performing the cleaning of its Air Cooler Condenser (ACC). The ACC system consists of twelve motors with A-frame design.

Previously, cleaning was carried out offline with wet process. Results were questionable and the cleaning only partial with risk of packing deposit inside the bundle.

The Decamex® process was proposed, offering a **dry online** alternative to the client with the following benefits:

- faster payback
- more effective
- complete cleaning of the surfaces and bundles

The Decamex® process, involving low air pressure cleaning, is easy to implement and very effective. Significant cost benefits were realised by performing the cleaning **online**.

To evaluate the efficiency, vacuum backpressure versus ambient temperature was monitored before and after the Decamex® cleaning.

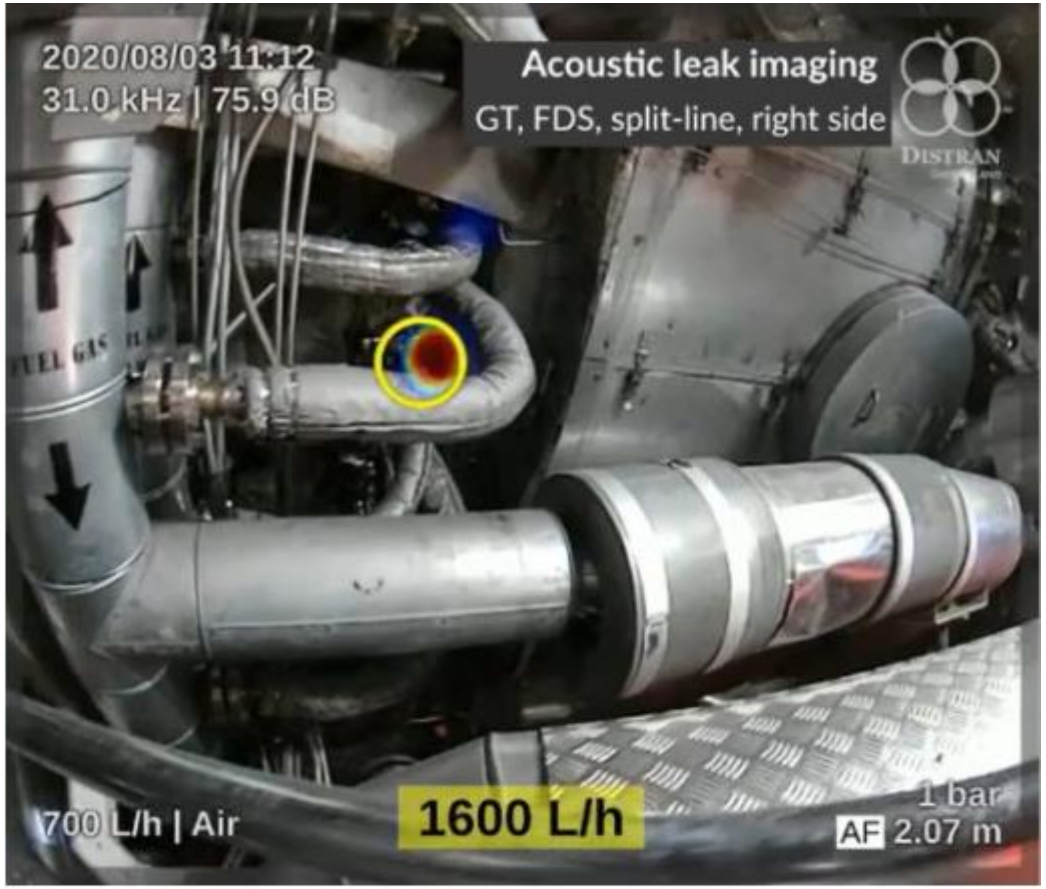
Results show a significant improvement (more than 20 %) on ACC performance despite a less favourable operational environment (ambient temperature rise). After the clean, the ACC is seen to be operating much closer to the design than previously.

The client has decided to carry out its ACC cleaning with CTP twice a year to maintain this unprecedented level of performance.

Our experienced team has developed new tools to comply with every design and configuration of ACC.

Air Leakage – Distran Ultrasound Cameras

Fouling – CTP Env Chemical Solution

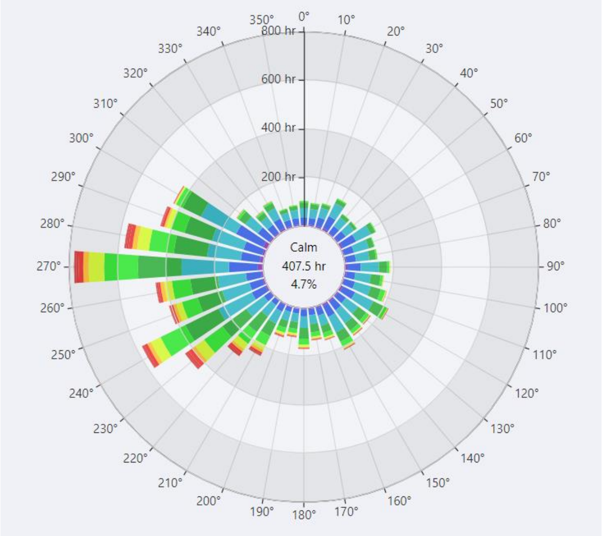


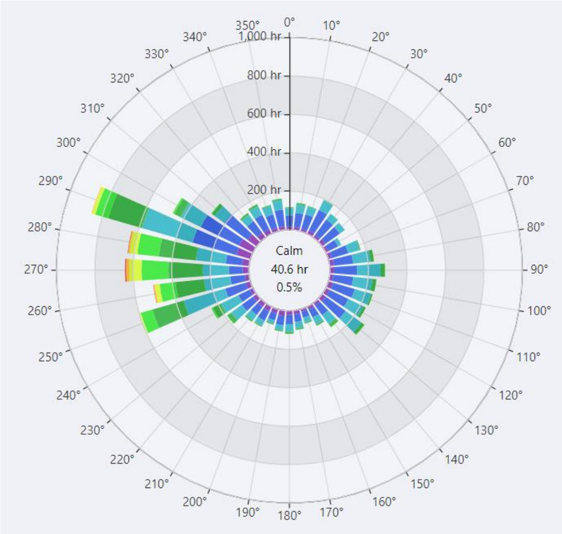
Galebreaker Collaboration

Ferrybridge engaged Galebreaker to review the effects of wind on the ACC.

To identify the effects of the wind and explore mitigating solutions using detailed CFD modelling of the plant.

- Prevailing winds from local weather stations indicate that the prevailing wind attacks the ACC on the corner of unit 2.
- Cross winds effect ACC performance by increasing static pressure on the fans and reducing airflow.
- Reduced airflow results in increased backpressure and reduced turbine efficiency.



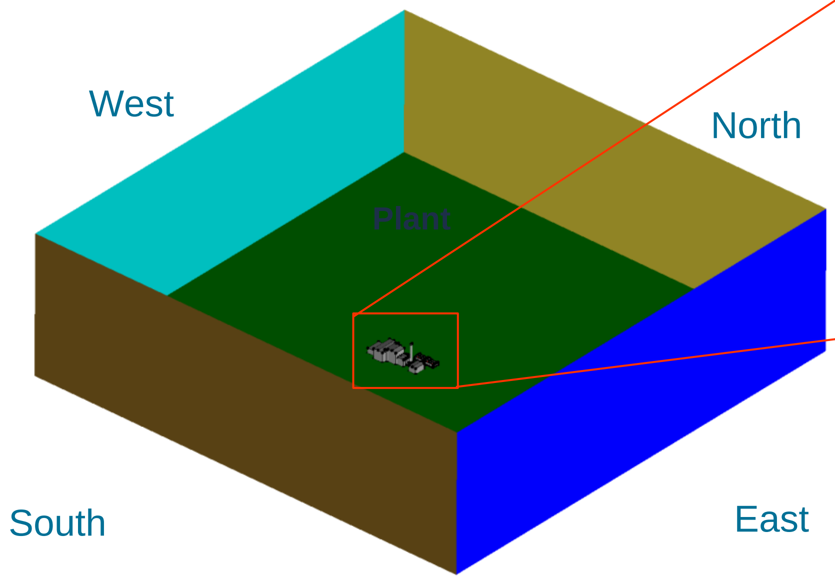


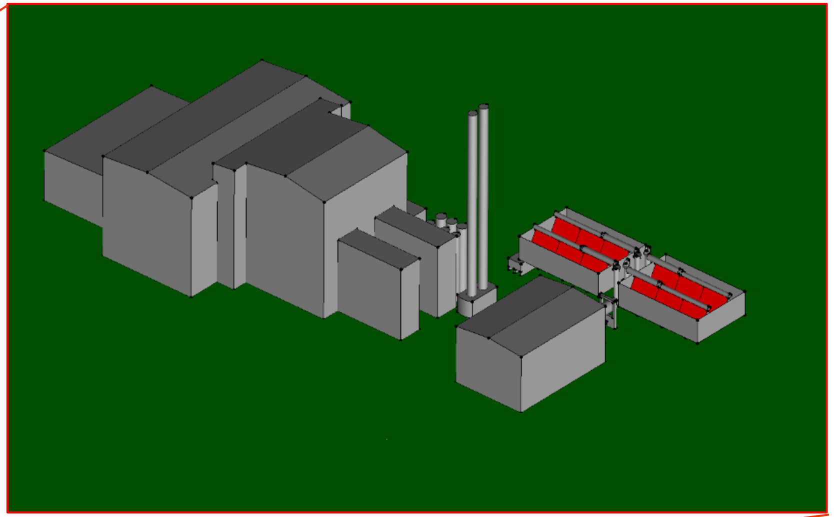
Geometry

Complete Plant Modelling

CFD Model Preparation

- Considers all local structures near to the ACC that will affect airflow
- Considers a large area to include relevant land features to ensure accurate modelling
- Air flow applied to remote surfaces of the model area on two faces, to simulate the direction of the airflow





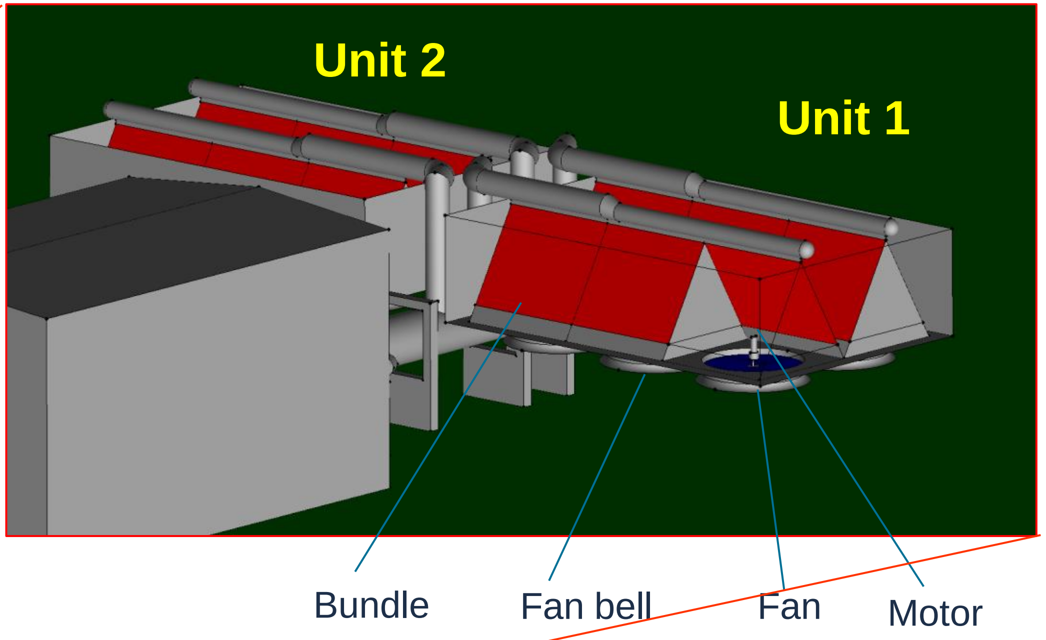
Plant Configuration

ACC Model

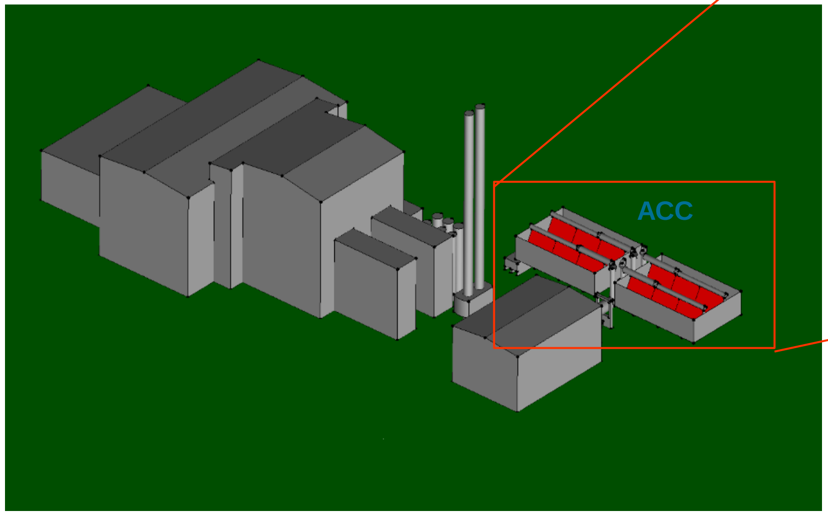
ACC Modelling

- Considers the dimensions of the main components, fan, tube bundles, header pipes and wind walls, as these effect airflow
- Main support structure is omitted from the model, as effects are considered negligible

South-East view



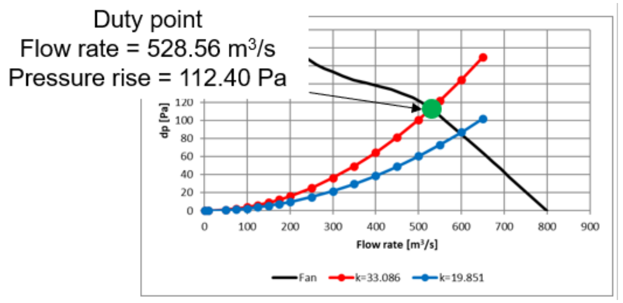
Plant



CFD Modelling

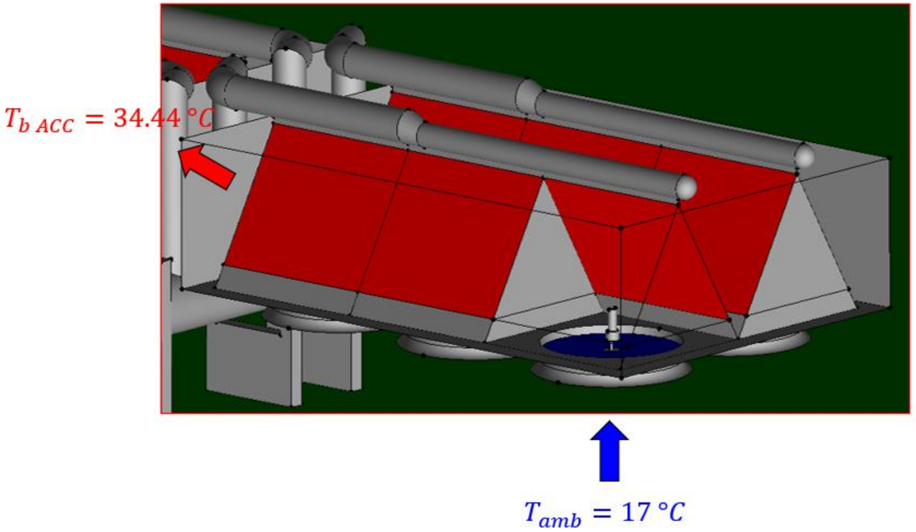
Reactive Functionality

Active surface sub-calculations created in the CFD model.



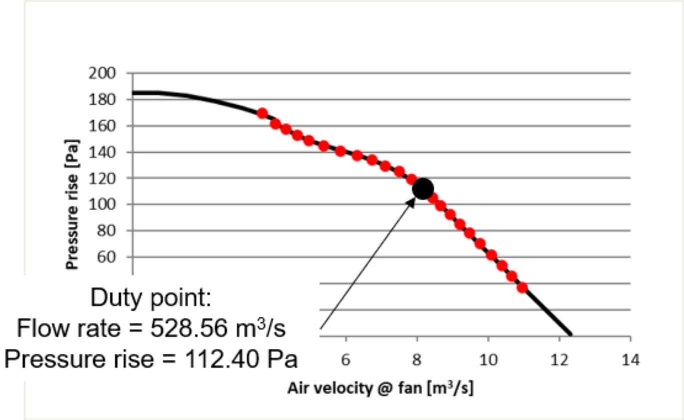
Bundles – Red Surfaces

- Bundle is modelled as a thin surface and implements:
- A sudden pressure drop
- A sudden temperature rise



Fans - Blue Surfaces

- Fans implement a sudden pressure rise (p) as a function of normal air velocity (V)
- The fan curve was generated based on the provided fan curve and was digitized and implemented in terms of analytical functions p=f(V)
- The fan curve is extended towards low flow rates to cover the full range of velocities

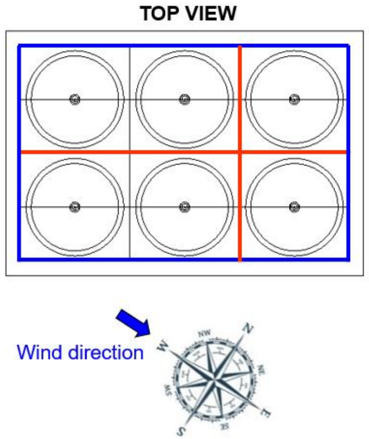


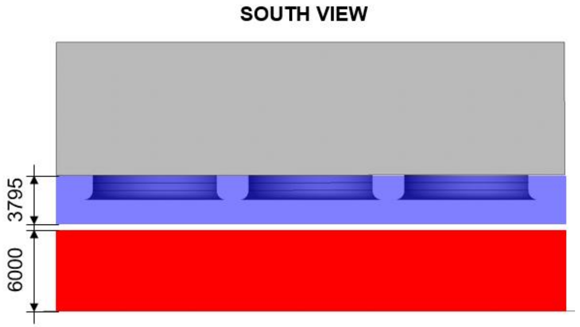
Using the sub-calculations contained within the model, variation in wind speed results in calculated changes in velocity and pressure drop which leading to variation in airflow created by the fans and experienced by the tube bundles.

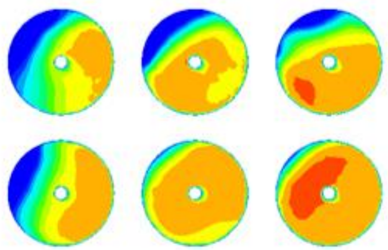
CFD Modelling

Analysing Results

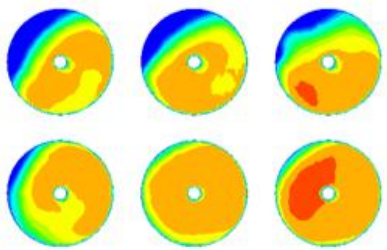
- Winds from the west, effect more than half of the ACC fans, leading to low flow regions
- The arrangement of the ACCs at Ferrybridge lead to more affected (perimter) fans due to the division of the 2 units
- Wind screens reduce the negative effects of the winds



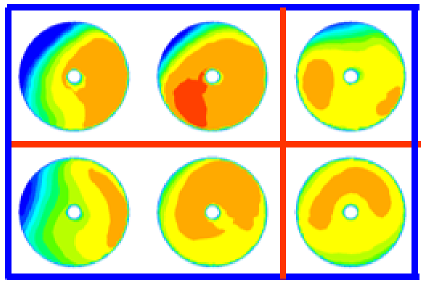




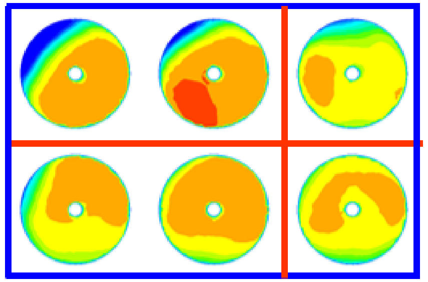
59.42	76.02	83.48
69.99	96.86	102.71



72.19	74.69	80.37
87.11	99.61	103.28



74.92	96.47	87.01
72.47	96.24	91.34



81.41	95.90	86.77
91.77	95.97	88.81

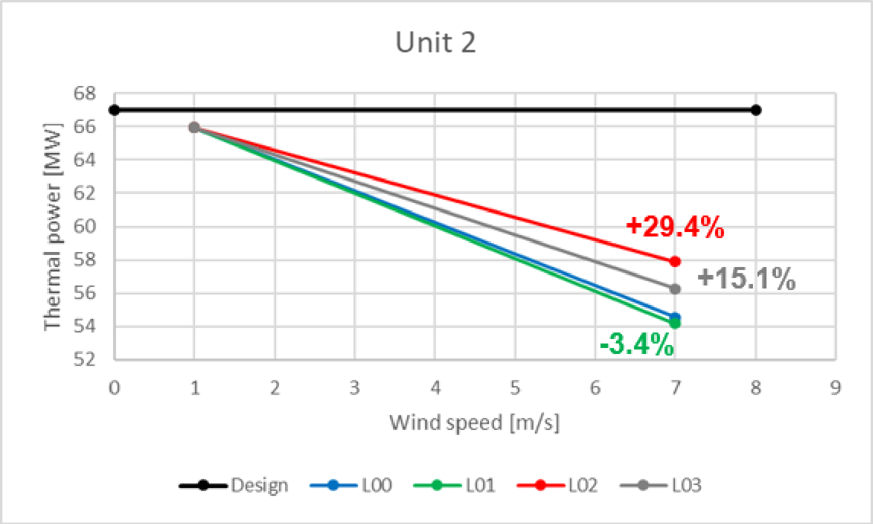
CFD Modelling

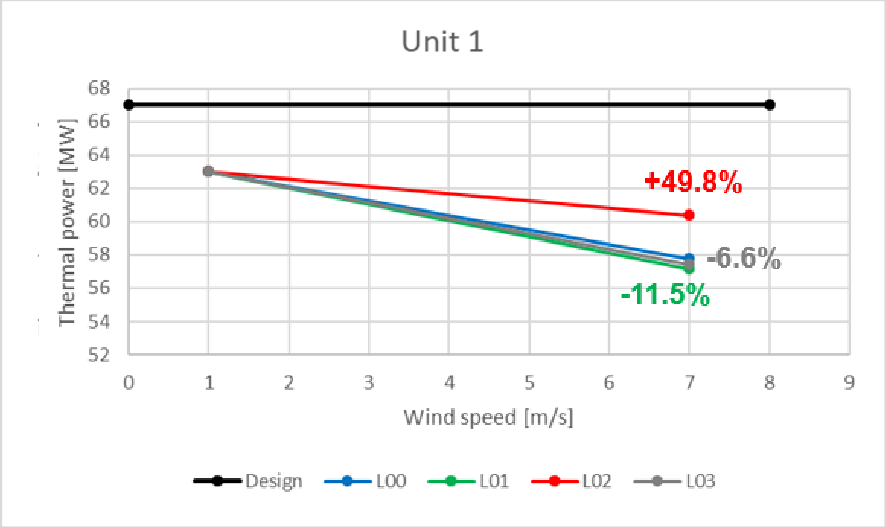
Evaluating effects under varying wind speeds

From many previous studies it has been observed that the effect on airflow has a virtually linear relationship to the increase in wind speed.

Using the results of the CFD modelling, graphs are created to demonstrate the effects at varying windspeed from the prevailing wind direction

- Unit 2 is the most heavily affected by the wind as this is the most exposed relative to the prevailing wind.
- Unit 1 is partially in the shadow of unit 2 and suffers a higher level of performance loss at lower wind speed, but a greater improvement following the installation of screens.

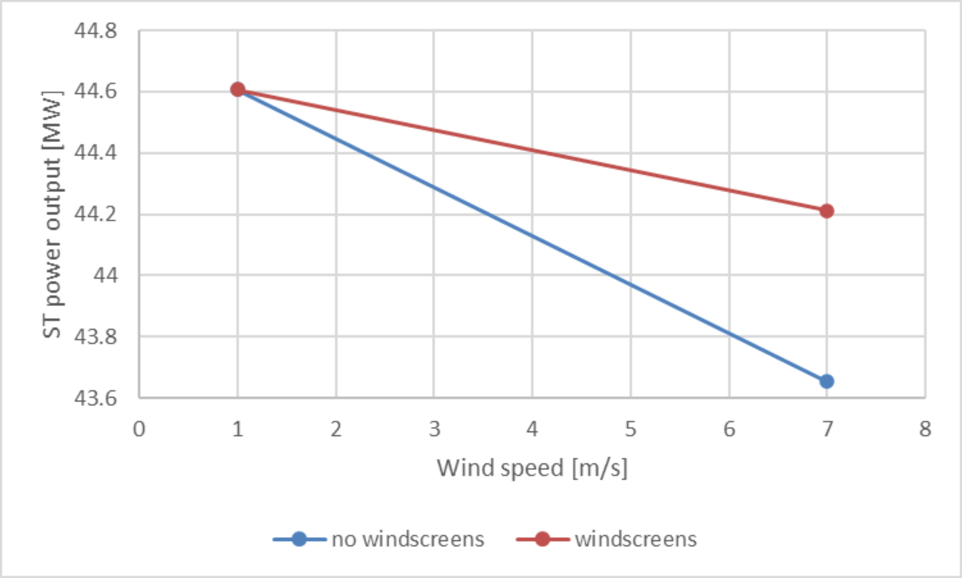


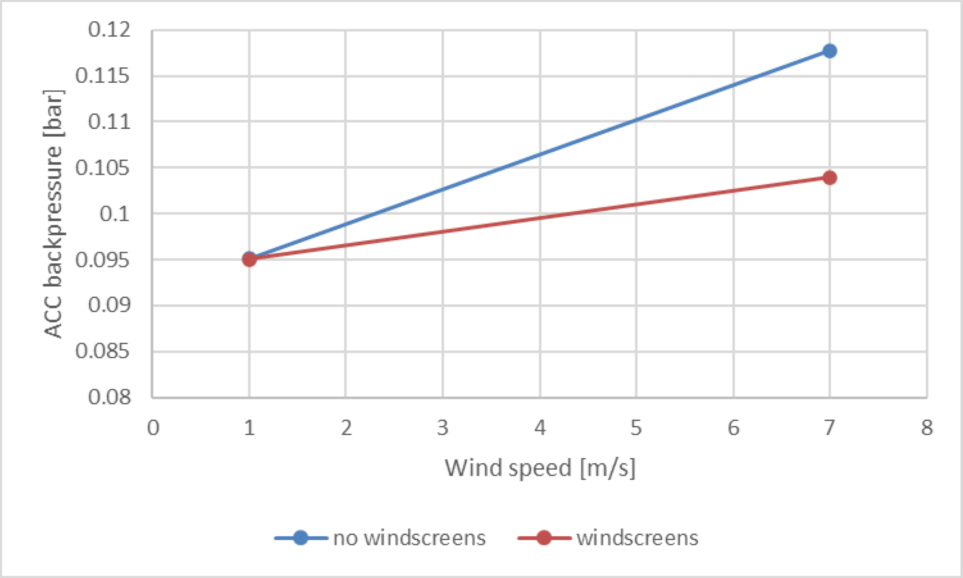


Post Processing of CFD Model

Digital Twin Modelling

- A digital twin was created and verified
  - Ambient temperature = 17 °C, Wind Direction = 270 deg, Wind Speed = 1 and 7 m/s

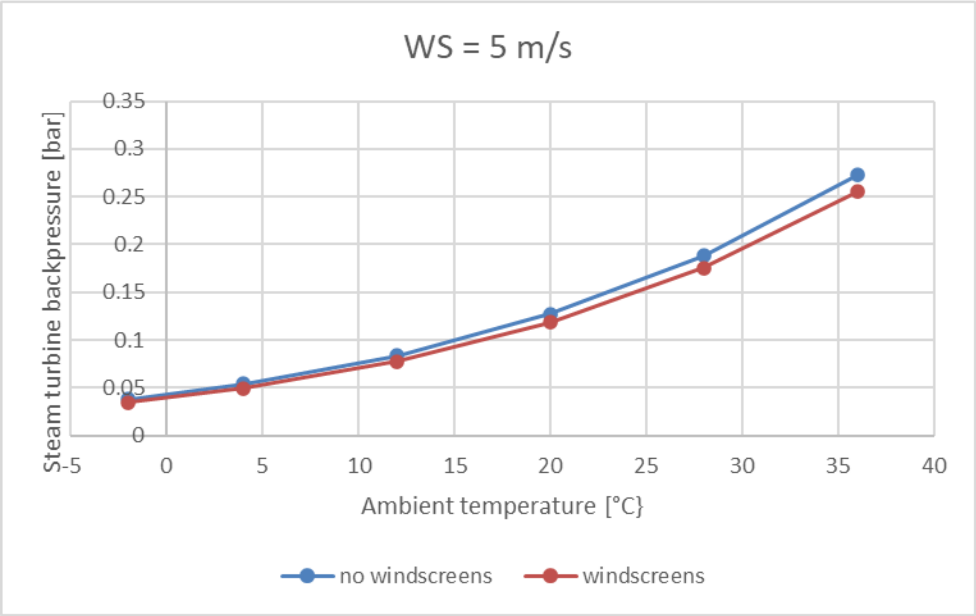


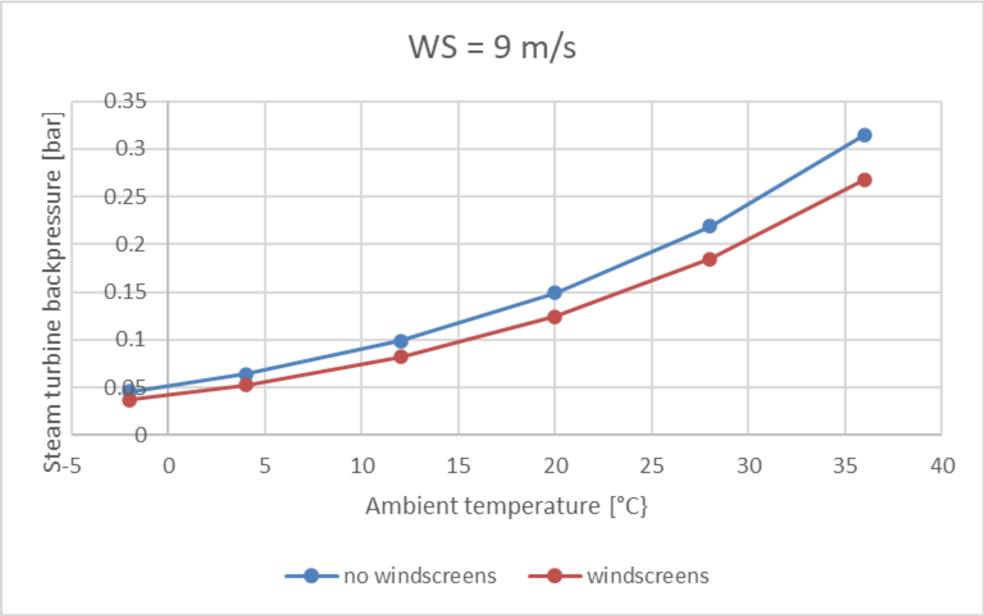


Post Processing of CFD Model

Digital Twin Modelling

- Different weather conditions were used to verify the model sensitivity to the principal parameters
  - Variable ambient temperature, fixed wind speed at 5 and 9 m/s (WS = 1m/s used as reference case)





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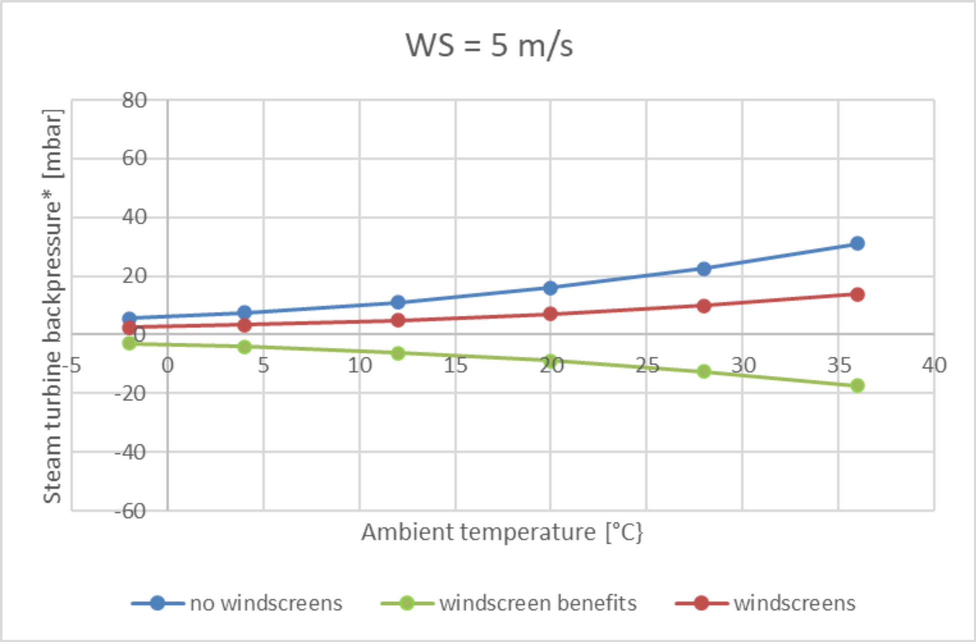
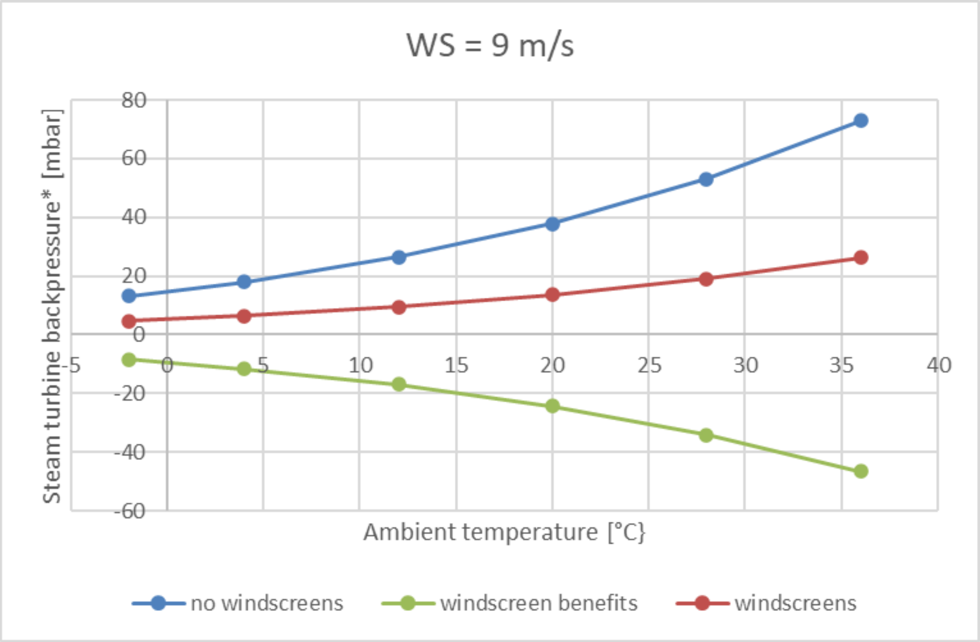
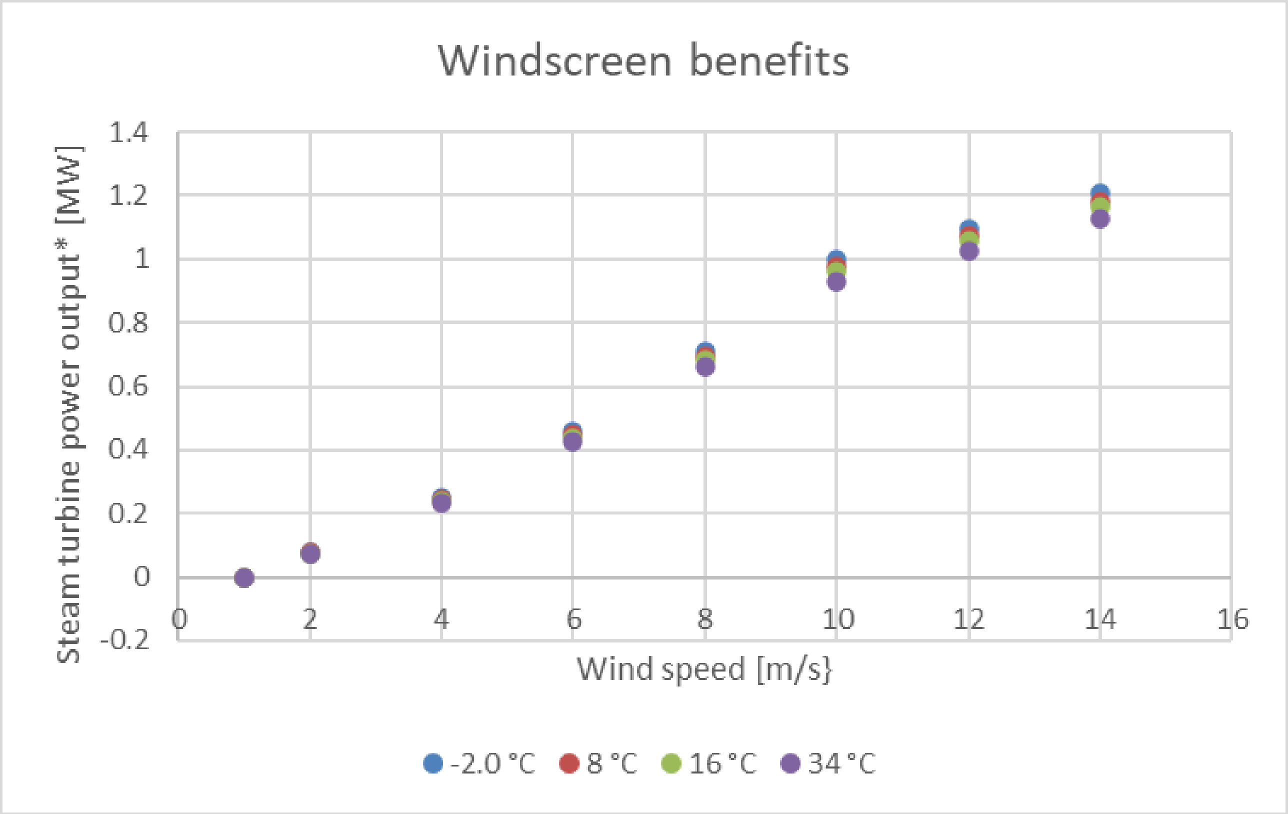




Post Processing of CFD Model

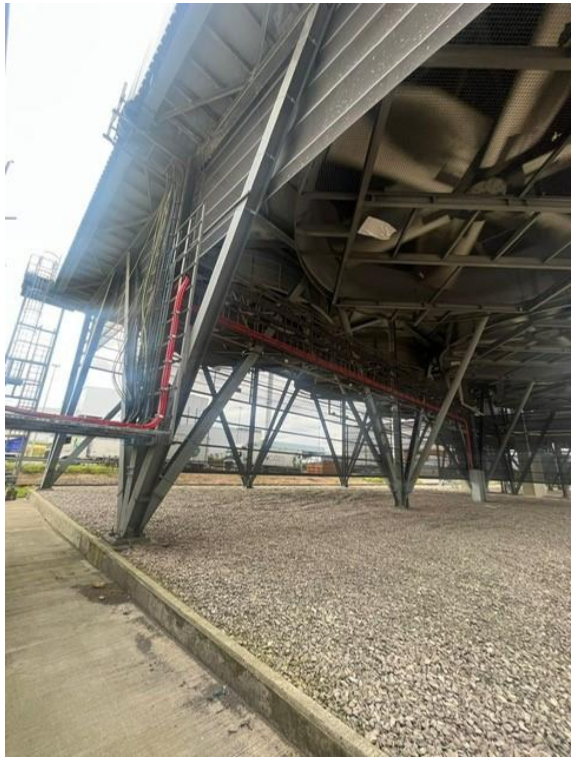
Digital Twin Modelling

- In summary, the windscreens benefits vary very little with ambient temperature while they depends largely on wind speed



Wind Screen Installation

Cruciform and Perimeter Screen Layout



Pre vs Post Windscreens

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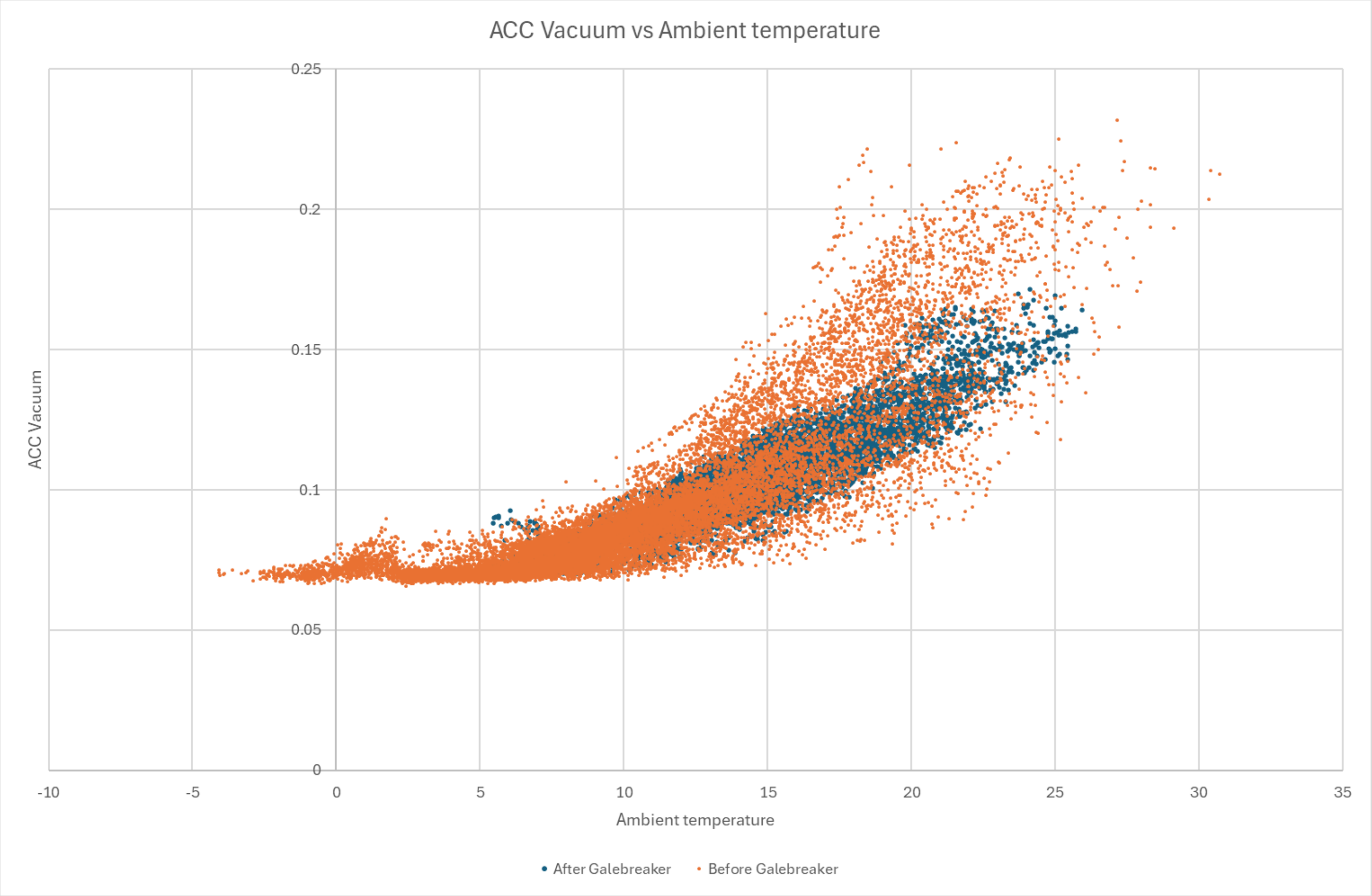
Key

Orange represents vacuum Pre installation.

Blue represents vacuum post installation.



F1 vs F2

F1 in Blue which has the windscreens vs F2 in Green which currently doesn't have the windscreens installed.